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PRODUCTION OF CERAMIC PIGMENTS BY POWER-SAVING TECHNOLOGY

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An original industrial prototype of a filtering unit made of porous metal has been designed and introduced in operation at the factory. A diagram and description of the set are provided, together with the principle of its operation. Practical recommendations are given.

Power-saving technologies, which at the same time contribute to solving environment-related technogenic problems, currently occupy the dominant position in the socioeconomic strategy.

The intensification of technological processes, the development of highly efficient power- and resource-saving systems, and the development and implementation of new machinery have sharply incremented the atmospheric discharge of dust and toxic gaseous impurities, which multiply exceed the current standards of maximum permissible discharge (MPD). In this context, the problem of reliable sanitary and technological dust recovery in the production of construction materials, in particular, in the production of ceramic pigments and paints, acquires special importance.

The traditional purification methods and dust-collecting equipment do not satisfy the contemporary MPD standards.

The development of waste-free technologies and the implementation of state-of-the-art dust-collecting plants at the existent ceramic factories encounters serious difficulties (severe shortage of production space and available energy, lack of funding for upgrades, personnel problems, the absence of professionally trained staff for operating dust-collecting systems, etc.).

The continuous improvement of dust-collecting systems brought about a certain decrease in the amount of toxic compounds released into the atmosphere with waste gases. The significant decrease in the total dust emissions was primarily accomplished through efficient trapping of solid suspended particles of diameter $d_p > 5 - 10$ µm. Solid particles with $d_p > 5$ µm, which represent the greatest danger to the human organism and constitute the most valuable part of wasted materials, are harder to trap, and the share of such particles in the overall atmospheric dust emission is constantly growing. Therefore, special attention is paid to catching such particles.

An important step in solving this problem is the development of fundamentally novel equipment which is competitive on the world market and whose engineering level surpasses the known foreign analogs. This problem is particularly essential in the dry-method for the production of ceramic pigments, which was developed by V. A. Goremykin.

The production growth of competitive pigments is based on the improvement of their physicochemical, color, and thermal properties and the implementation of new energy-saving production equipment. Special attention is paid to the protection of the ambient medium and simultaneous utilization of recovered dust (which is a valuable product).

Granular filters are promising for highly efficient dry dust collection. Their advantages consist in a high degree of purification, high strength and heat resistance, good permeability, capability to withstand abrupt variations of pressure, good corrosion resistance, ability for regeneration using various methods, and simplicity and variety of combination variants of individual filtering elements. However, what is still missing is a specialized fine filter intended for the production of ceramic pigments and paints, with specific design and service characteristics. In designing such filters, one encounters the problem of selection of a filtering material, which ought to have the optimum set of hydrodynamic and physiochemical properties.

The available data of studying fine purification systems for dust-gas flows are insufficient for the design of such specialized filters, since they do not take into account the specifics of pigment production. The problem of combining increased purification efficiency with decreased hydraulic resistance and reduced dimensions of the equipment requires special attention and has not been solved yet. All these problems call for the development of a highly efficient dust purification technology for aspirated discharges generated in the production of ceramic pigments based on the energy-saving technology.

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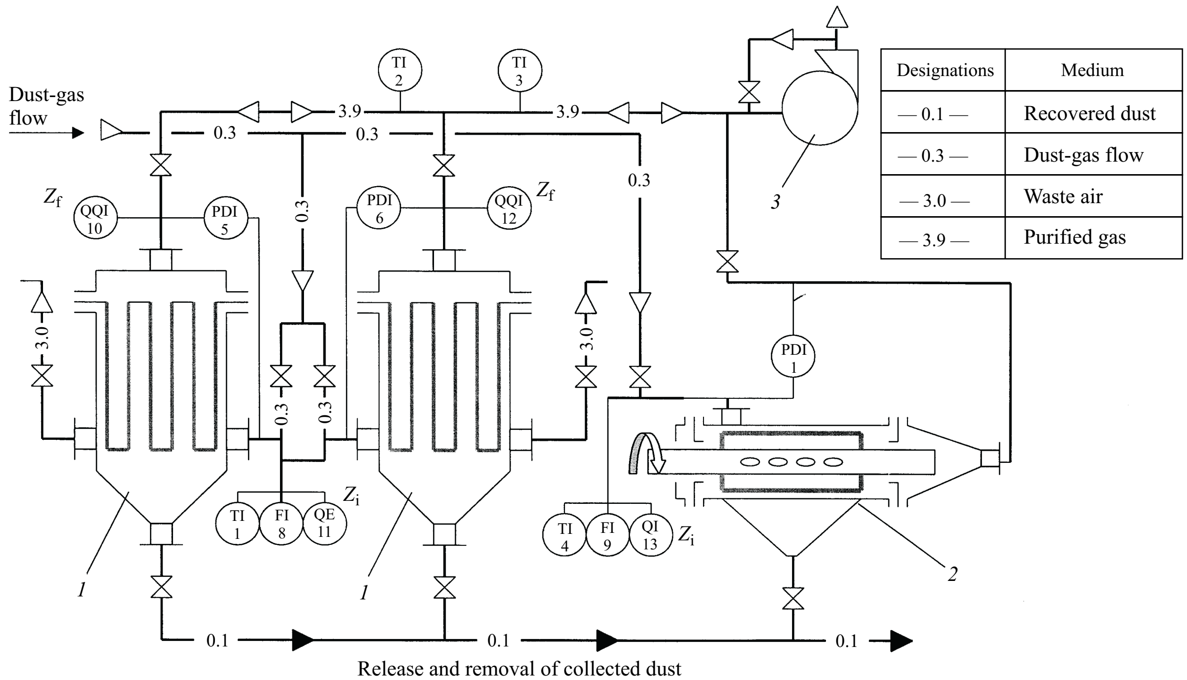

Fig. 1. Diagram of prototype industrial filtering set made of porous metals: *1*) filtering cartridges with deployed surface; *2*) rotary filter; *3*) fan; TI) temperature; PDI) pressure difference; FI) flow rate; QE) mass concentration of dust; QQI) count concentration of dust.

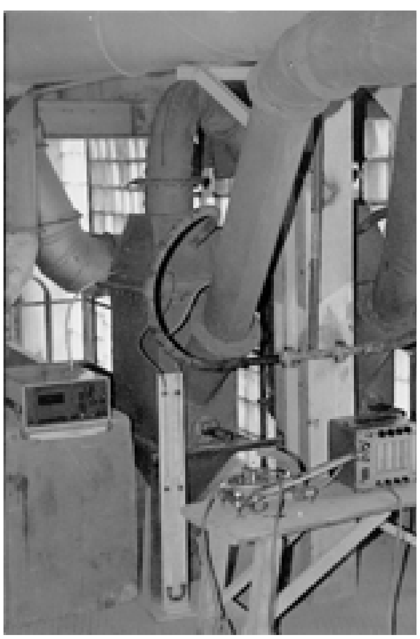

Fig. 2. Prototype industrial set with filter cartridges.

Figure 1 shows the diagram of the prototype industrial filtering unit made of porous metals at the Voronezh Ceramic Factory, which was developed at the Voronezh State Technological Academy together with the factory specialists.

A technological gas or an aspirated dust-gas flow arrives to the cartridges arranged in parallel, with deployed filtering surface, or to the rotary filter, and the purified gas is propelled into the atmosphere by a fan. The filtering cartridges are regenerated with air purified from dust, employing pulse fan blowing via a system of valves.

The filtering cartridge material was porous stainless steel of grade PNS-5 (Kh18N15-PM) produced at the Vyksunskii Metallurgical Works. The size of each cartridge is $0.40 \times 0.40 \times 0.25$ m. The thickness of the material is 3 mm, the porosity 0.26%. The total filtering surface of two cartridges is 4.24 m^2. The rate of the dust-gas flow (a VVD-8 fan) is 1500 m^3/h. The specific gas load in this case is up to 6 m^3/(m$^2 \cdot$ min). The maximum hydraulic resistance is 6500 Pa.

With the input dust concentration up to 1.5 g/nm^3, the output dust concentration did not exceed 5×10^{-4} g/nm^3, and the efficiency reached 99.96%, which should be recognized as highly satisfactory. The filtering cartridges with deployed surface represent a module solution. The arrangement of such parallel modules makes it possible to provide an efficiency of up to 20 thousand m^3/h of dust-gas flow.

The filtering efficiency was additionally monitored by a PK.GTA-03 aerosol particle counter, counting particles of size ranging from 0.5 to 1.0 μm.

The preferable regeneration method for metal ceramic filtering elements is pulse blowing, employing purified gas or compressed air, in the direction opposite to the filtering of the dust-gas flow, as well as regeneration by means of developing a dynamic force near the filtering surface.

The air for regeneration is supplied from a source into the filter body to each filtering element via a distributing de-

TABLE 1

De-dusted equipment	Material	Waste gas volume, m^3/h	Classification group characteristics					Dust-collection scheme	
			dust-gas flow			dust		stage I	stage II
			dust content, g/m^3	temperature, °C	main fraction, %	wettability, %	adhesion, 10^3 Pa		
Charging abinet	Dust from zinc dioxide, quartz sand, sodium silicofluoride, cobalt oxide, alumina, chromium oxide, titanium dioxide	1650	1.5 – 3.5	10 – 30	Below 30 μm, 49 – 54	Good and medium wettability, 52 – 72	Weak and medium adhesion, 0.08 – 0.20	STsN-40 and SDK cyclones Vortex devices	Porous metal filter
Dry-milling ball mill	Pigment batch	1500	2.4 – 5.8	10 – 30	Below 20 μm, 70 – 86	The same	Medium and strong adhesion, 0.30 – 1.52	STsN-40 and SDK cyclones Vortex devices FTsZ and FTsGM granular filters	The same
Wet-milling ball mill	The same	1500	2 – 3	10 – 20	Below 20 μm, 60 – 84	Good and medium wettability, 64 – 86	The same	The same	″
Sagger-ramming unit	Pigment batch, dry pigment dust	1870	1.01 – 1.8	10 – 70	Below 30 μm, 91 – 95	Good and medium wettability, 52 – 72	″	STsN-40 and SDK cyclones Vortex devices	″
Fine-milling colloid mill	Dry pigment dust	1500	1.865 – 5.0	10 – 30	Below 10 μm, 80 – 94	Good wettability, 60 – 90	″	STsN-40 and SDK cyclones Vortex devices FTsZ and FTsGM granular filters	″

vice by means of shifting a branch pipe. The regeneration is recurrent (upon reaching a certain level of pressure differential).

The prototype industrial set with filter cartridges made of PNS-5 porous metal (Fig. 2) is installed in Workshop No. 5 of the Voronezh Ceramic Factory at the site of fine milling of ceramic pigments.

The kinetic regularities of the filtering process with simultaneous sediment deposition on the surface and filling the pores of the filter membrane were obtained and tested in industrial conditions. The optimum value of specific gas load was determined using iteration methods. New upgraded methods for dust sampling and disperse analysis of particles were implemented in the factory laboratories.

The kinetics of separation of aerosols with a disperse solid phase by rotary cylindrical filter elements was investigated. The filtering element in the experiment was a cylinder of diameter 40 × 4 mm and length 100 mm made of spherical powder of stainless steel (steel grade OKh18N10, fraction < 0.063 mm).

The convenience of using a rotary filter consists in ensuring stable hydrodynamic conditions and decreasing the hydraulic resistance, which makes it possible to abandon regeneration as it is traditionally understood, while preserving a constant high efficiency.

The obtained results were used at the Voronezh Factory to install a highly efficient dust-collecting system in the production of ceramic pigments and paints.

Based on the developed method for fine purification of aspirated discharges, a classification table was composed for the selection of dust-collecting systems and equipment in the production of ceramic pigments.

The developed system provides for two-stage purification of gas: the first stage involves highly efficient STsN-40 and SDK cyclones, vortex devices, bulk granular filters or chain filters FTsGM and FTS-1P(1E); and the second stage is based on filtering elements made of porous metals. The efficiency of such a system in trapping particles of size over 0.3 μm is 99.99%.

The promising systems, in our opinion, are systems with a moving filtering layer and recurrent or continuous removal of the part of the layer with recovered dust to be regenerated. Such filters are particularly expedient, if the filtering medium together with the recovered dust can be used directly in the production process.

The obtained results can be recommended to manufacturers of construction materials, the food and chemical industry, ferrous and nonferrous metallurgical industry, and the traditional and nuclear power industry.